

# 49. Warning Coloration in a Nudibranch Mollusc and in a Chameleon. By CYRIL CROSSLAND, F.Z.S.

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## I. WARNING COLORATION IN *CHROMODORIS*.

Since the discovery of warning coloration there has been a tendency to attribute protective value to displays of brilliant tints which further observation has rendered doubtful, and the instances in which actual protection has been experimentally proved are not so numerous but that one more has some value.

The Chromodorids are, as their name implies, a family of Nudibranchs characterised by the development of colour shown by all its members. Having collected a large number during the past ten years, I may say that none of the family has been wanting in this characteristic, except perhaps *Casella atromarginata*, which, though handsomely, is not brilliantly, tinted. In this I merely corroborate the general experience of marine collectors. Besides this universality of colour the family is well defined structurally; indeed for the class the structure is remarkably uniform. The usual depressed form of body, more or less ample margin, broad foot, and feathery, usually tripinnate gills, are, in the more typical Chromodorids, replaced by the opposite characters. A narrow foot underlies a high body, the mantle is a mere shelf along the top of its vertical sides, and the gills are simply pinnate\*. Internally the stomach is entirely embedded in the liver.

There is a smaller section of the family in which these characters are less marked, the body having a wider mantle; in some species a few of the gills are branched and the stomach is partly free from the liver, thus indicating a connection with the ordinary forms.

Otherwise structure is so uniform throughout the group, that without detailed description of the colours of the living animal identification of the species is impossible. Even with this description in full, determination of species is difficult, variation being very considerable so that, *e. g.*, what one observer sees as black bands on a white ground is to another white lines on a black body†.

\* Are these simply-pinnate gills the primitive form of Nudibranch gill, a modification of the prosobranch ctenidium? The highly specialised Chromodorids supply the answer, since it is the less specialised members of the family that have the more complex gills. A detailed study of the Chromodorid gill would show that its structure is more complex than the term "simply pinnate" leads one to suppose, and possibly would show details of higher organisation than do the tripinnate feathery gills of ordinary Dorids. In the development of these gills from an originally irregular vascular flap of skin, the tripinnate arrangement would be the earlier stage to be reached.

† *Chromodoris quadricolor* Eliot, Journ. Linn. Soc., Zool. xxxi. Nov. 1908, p. 107 = *C. elizabethina*, P. Z. S. 1904, p. 392, Pl. xxiv. fig. 4. Some other Chromodorids are here figured including *C. nigrostriata*, a variety of the *C. diardi* referred to later in this paper and a good example of the variation now discussed.

The family is therefore probably monophyletic (so far as any family can be), and it would seem that the power of colour production is a single character, which, in a few of the cases in which it has arisen, was associated with distastefulness or other protective quality, and so, possessing a great survival value, led to the foundation of the family. What colour or pattern might be produced selection cared not, so long as it were conspicuous in the eyes of nudibranch enemies, and duly correlated with inedibility\*.

Hence the multitude of patterns and colours found in this one class, and the variation above mentioned. Possibly one colour is much the same as another in the biochemistry of the animal, though so different to the human eye†.

The survival value of the devices is evident from the abundance of species in tropical waters. In collections, while species are numerous, individuals are usually rare, but the peculiar habits of many nudibranchs, which suddenly appear in local swarms and shortly disappear again completely, show that as in, *e. g.*, the case of the Sharks of St. Andrews Bay‡, which were not known to exist there until new fishing methods were introduced, the proportions in which species occur in collections are not at all those in which they live in the sea. Of the Chromodorids I remember particularly *C. annulata*, *C. sykesi*, *C. hilaris*, and *Ceratosoma cornigerum* as occurring for a few days in quite local swarms, then disappearing absolutely; while during the past fortnight a hundred specimens of *C. reticulata* [Pl. LXI. (p. 1068)] could quickly be collected within a few yards of where I write, but to-morrow there may be not one.

The collection would be the more easy in that this species like all Chromodorids crawls about in the open instead of skulking under stones or in crannies after the fashion of most of the class, except of course at low tide when it would otherwise be killed by the sun.

In contrast with this, the general inconspicuousness of most Opisthobranchs culminates in many cases in adaptations which result in resemblance to surroundings so striking and so well in accord with the observed habitat, that there can be no doubt as to protection being afforded by them§.

\* Amidst this diversity we find that in all Chromodorids the edge of the mantle is specially coloured. In others the gills and rhinophores are coloured differently from the rest of the body, as in the case of *C. diardii*.

† That the colour of marine animals is often connected with their essential physiology or apparatus of reproduction is indicated by the many cases in which the eggs of a species are deeply coloured with the principal body colours of the parents. This is conspicuously the case with numerous species of Polychæta and Nudibranchs. The Chromodorid hereafter described under the name of *C. reticulata* lays eggs the colour of the yellow bands on the mantle. The purple band secretes mucus of the same tint, so that probably the purple colour has its physiological use, as well as warning colour value.

‡ McIntosh, W. C., "Notes from the Gatty Marine Laboratory," Ann. Nat. Hist. vol. x. p. 254, 1902.

§ I have never had the fortune to possess a properly stocked aquarium in which experiments on this side of the theory could be undertaken.

Two interesting facts are worth recording of the coloration of several species of Tectibranchs, which besides being close simulacra of their environment in other respects, each occur in green and brown varieties, simulating green or brown weeds, or at least in one case, the old and young shoots of *Zostera*. Living specimens of these species are not now within my reach or further details might be given, and sketches. The same thing happens in a Scyllaeid\*, the brilliant green and the brown forms of which are found near together in Chuaka Bay, Zanzibar, whilst greenish to deep brown varieties occur here (Dongonab) in the Red Sea†. The other point about the coloration of these forms (Scyllaeid and Tectibranchs) is the occurrence in so many species of small brilliant blue spots, sometimes ringed with yellow, the only conspicuous thing about otherwise scarcely visible creatures. These *may* be "recognition marks" but are more likely to be glands‡.

We have then an excellent case for the theory that the brilliant colour of these animals has a protective value. They walk abroad where others must creep and hide.

Distastefulness was proved by trying to feed fish with specimens (mostly *C. reticulata*, twice with *C. diardii*) thrown from the windows of my houseboat. The kitchen refuse, and the shelter afforded from the sun had made the surrounding water populous with fish, and on a calm morning every detail of their movements was clear. The water was shallow, the bottom sandy, with a covering of short "sea grass," the usual habitat of several fish and often of considerable numbers of *Chromodoris reticulata*, more rarely of *C. diardii*.

The Garfish, *Belone* sp., is the only one of these animals with a specialised diet. It is ever on the watch floating near the surface, herding together the shoals of "sardines" (*Engraulis* ? *boelama*),

\* *Crosslandia viridis* Eliot, P. Z. S. 1902, pp. 64-68; *C. fusca* Eliot, Journ. Linn. Soc., Zool. xxxi. 1908, p. 90.

† The green Zanzibar specimen was found on *Zostera*, which is less abundant in the Red Sea and from which I have not yet obtained this species.

‡ Other brilliantly coloured Nudibranch families are the Polyceridae and Aeolidae. Of the former I have seen too few specimens to generalise, but one of the most beautiful, the wine-red *Plocamopherus ocellatus*, was merely a lighter tint of the colour of its environment, a deep red polyzoan on which it fed. There is some evidence that it owes part of its colour to its food-stuff.<sup>1</sup> Another, *Trochelyxana crocea* <sup>2</sup>, is a little slug-shaped beast of a brilliant yellow colour. It periodically occurred in great swarms in Chuaka Bay, Zanzibar, in the open, not hiding in any way. The Aeolids are all bright coloured, I believe, and all, or nearly all, gain protection by living amongst hydroid zoophytes, and even can utilise the stinging-thread cells of the latter in their own bodies.

Tritonids often live among zoophytes, in Zanzibar often among fleshy Alcyonaria, and are fairly conspicuously coloured. But *Melibe fimbriata*, a large animal, in colour and in the shape of its cerata and the processes it bears, looks extremely like a fragment of drifting fucus-weed.

<sup>1</sup> Eliot, Sir C., "Marine Biology of the Sudanese Red Sea," Journ. Linn. Soc. xxxi. Nov. 1908, p. 104.

<sup>2</sup> Eliot, Sir C., "Nudibranchs from East Africa and Zanzibar," P. Z. S. 1904, vol. ii. p. 87.

occasionally making dashes into the shallow water and carrying off stragglers. Yet even *Belone* dashes up for any bait thrown into the water, though the portions that sink below the surface are left to the numerous bottom feeders. Of these we have *Chrysophrys bifasciata*, *Pimelepturus cinerescens*, and two other species which I have not identified, and they will eat, or have become accustomed to eating, almost anything, including shelled specimens of *Margaritifera vulgaris* which had been kept in formalin for three weeks, and the guts of *Balistes flavimarginatus* and *B. viridescens* which had been in the same preservative overnight. *Pimelepturus* eats the fresh viscera of its own species, or the pure white cooked flesh of *Caranx* sp. equally readily. But none of these five fishes will eat either of these two species of *Chromodoris*; attracted by the splash they dashed up to them as to any other bait, but one fish after another, of each species, as the nudibranch sank, at once turned away after just touching it. Examples of *Chrysophrys* took the animals into their mouths, but at once dropped them undamaged.

The behaviour of *Pimelepturus* was particularly interesting. If a specimen of *C. reticulata*, which is white underneath (but for a few purple spots under the edge of the mantle), fell on the sand wrong side up, the fish would at once attempt to take it. If, however, the slug fell right side up, so displaying its gorgeous mantle, *Pimelepturus*, swimming over it a few inches away, took no more notice of it than of a stone.

What actually prevented these numerous fishes, of five distinct species, from swallowing the *Chromodorids*? One can hardly believe that a living slug could have a flavour more powerful than that of formalin! Moreover, these two species have no odour sensible to human organs, as have so many marine organisms, including the Chromodorid *Ceratosoma cornigerum*, and the Tritonid *Melibe jimbricata*. The behaviour of these fishes, which had for some weeks been feeding upon all kinds of kitchen refuse, and especially the fact that when presenting an *un-usual* appearance *Chromodoris* momentarily attracted them, disposes of the objection that they merely refused to eat an object which was strange to them. Indeed, the natural circumstances of the case make it impossible that *C. reticulata* should be unfamiliar to any of these fishes except *Belone*.

But that this objection is a weighty one and in all supposititious cases of protective coloration must be carefully considered, the following examples will show.

The camels of the southern part of the Red Sea Province get desert grazing all the year round, and are not fed upon "dûra" corn (*Sorghum*) in the summer. The consequence is that a southern camel has actually to be taught with much patience (for he deserves all that Kipling said about him) to eat corn. The feast may be spread before him, but eat it he will not, until his owner, seizing him by the nostrils, pours the corn into his mouth with the other hand, spite of his groaning protests. Indeed some

camels never get beyond this stage, and however hungry hold their heads in the air above the pile of corn, crying like spoiled children until the owner comes to feed them.

Contrast with this the behaviour of my two tame gazelles. From six weeks old to maturity they fed on milk, corn, and occasionally native leguminous plants. When fully adult they were introduced to bread, sweet biscuits, sugar, green corn-stalks, and the leaves of *Acacia tortilis*, all of which they ate readily without the stimulus of hunger. I once tried to feed a sick camel on stale bread, by way of invalid diet. It was impossible.

Another case is rather like that of the pigeons that starved rather than eat a strange seed. I tried to change the feeding place of my fowls by throwing their corn a yard or two to one side of the usual place in the direction of the new one. When called the fowls rushed up, stopped dead at the accustomed spot, and nothing would make them move a foot beyond it. We can pair the fowls with the opposite case, as we did the camels with the gazelles. The land crab *Ocypode* makes its burrows a little above high-water mark and never more than a yard or two higher up. But where the camels and fowls were regularly fed, the ground is full of the holes of these crabs ten or twenty yards above their usual habitat. Also, instead of confining themselves to their accustomed diet of dead fish, these lively crabs are ready for any experiment, from sweet biscuits to handkerchiefs, and some must now be living on camel dung and corn.

There are no oysters in Jerusalem, and consequently a native of that city cannot be persuaded to try one. He has no religious prejudice, or other dislike, but "No, I do not know them" is his sufficient reason.

## II. WARNING COLORATION IN A CHAMELEON.

I have not seen the fact recorded that the Chameleon (*Chameleon* sp.) can change its colour so quickly as to frighten a dog. While staying in Zanzibar my host's fox terrier showed hostile interest in a chameleon someone had brought into the house. The chameleon invariably tried to run away when attacked, but those who know the species can imagine the ludicrous ineffectiveness of a chameleon's flight. In a few seconds the impossibility of escape seemed to reach the animal's brain, when it at once turned round, opened its great pink mouth in the face of the advancing foe, at the same time rapidly changing colour, becoming almost black. This ruse succeeded every time, the dog turning off at once. Among the natural leafy surroundings of a chameleon the startling effect of its sudden change of colour would be much greater. Imagine a dog or cat nosing about suspicious of the presence of a live animal, but unable to see anything. Until almost touching him the chameleon sits close, secure in his mantle of invisibility. Then suddenly,



when the dog's nose is within six inches of him, the sudden change from invisibility to the conspicuous black body and great red mouth! I think many human beings would be startled, and in fact the natives of Zanzibar hold the chameleon in horror, and cannot be persuaded that its bite is not deadly. I tried the effect upon some of them on my way home. The ordinary native will show great caution, but no panic, when a chameleon is handled by a white man. I presented my specimen *unexpectedly* to several parties I met on the road, thus:—

On approaching, "Good morning," which was quietly responded to.

Just after passing, "See what a nice creature is walking on my back." Shrieks, and a stampede of fifty yards.

The specimen showed the ordinary light and irritation reactions which have been frequently recorded.